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Abstract

Theoretical Kinetic Studies of Boiling Water Reactors and Multiregion Reactors

Tsutom KANAI and Toshio KAWAI — Hitachi Central Research Laboratory
Junichi MIIDA and Nobuhide SUDA — Japan Atomic Energy Research Institute
Shigehiro AN and Akira OYAMA — Tokyo University

This paper consists of two parts. The first concerns a theoretical dynamic analysis of boiling water reactors, the second part is an analysis of multiregion reactor kinetics. The first part begins with the derivation of the equations describing the transient void formation in the core, then these equations are simplified and combined with other equations to form a complete mathematical model of the boiling water reactors. Finally, using the model, the reactor stability is investigated.

A simplified "void equation", describing the time-space dependent behavior of void volume fraction due to changes of reactor power, subcooling, inlet coolant velocity and system pressure, has been derived from the conservation laws of mass and energy, and numerical computations have been performed for transient void reactivity, using this void equation and the ordinary perturbation theory.

To supplement the validity of the void equation, the effect of momentum conservation is then considered. As a result two kinds of disturbances are identified, the usual void and the suppressed void by pressure wave. Although the velocity of pressure wave has been calculated to be very small in the steam-water mixture, it is considered to be still large enough for the high pressure transient. If the fast transient caused by a pressure transmission in the core is ignored, the equation resuces to the void equation previously discussed.

The void transfer functions are obtained by linearizing the void equation. Here uniform power distribution is assumed and the slip is ignored. Aside from these two simplifications, the resultant transfer functions are the most complete

distributed parameter model ever developed.

In addition to the void transfer functions, a complete set of other transfer functions is derived, namely, the inlet velocity transfer function, the vessel pressure tansfer function, the subcooling tansfer function and the recirculation flow transfer function.

The transfer functions derived above are further simplified and approximated by combinations of single time constant delays, whose time constants and static gains are readily evaluated from design parameters.

The dynamic characteristics of feedback transfer functions and the system stability are also investigated.

In the second part an analysis of multiregion reactor kinetics is undertaken, with the use of perturbation method and regional kinetics. In the perturbation method equations are introduced relating reactor period to perturbation conditions for multiregion reactor. These equations are applied for calculating the reactor periods associated with variation of thickness of reflector and for examining the inhour-equation. In regional kinetics one set of regional kinetics equations is derived by integrating the time dependent diffusion equation over each region of the reactor. These equations are expressed in explicit terms of physical parameters of each region. Based on these equations transfer functions and frequency characteristics of each region are examined.